AN INVESTIGATION OF THE INFLUENCE OF CYCLING OF SCIENCE 10 AND 20 ON ACHIEVEMENT IN CHEMISTRY 30 AND PHYSICE 30

by

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November 1957

FACULTY OF EDUCATION

AN INVESTIGATION OF THE INFLUENCE OF CYCLING OF SCIENCE 10 AND 20 ON ACHIEVEMENT IN CHEMISTRY 30 AND PHYSICS 30

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CHAPTER I

STATEMENT OF PROBLEM

All subjects which may be taught in a small high school are listed among those appearing on pages 8 and 9 of the Handbook. However, since small high schools offer somewhat restricted programs, certain arrangements may be entered into concerning courses most commonly taught.

The total enrolment, resulting from combining classes of two grades, may be a factor determining the extent to which the suggested arrangements will be employed. Details of these arrangements are as follows:

(a) i. The practice of cycling Grade ten and eleven courses, and of combining these grades for instruction, may be applied to:

Language 10 and 20
Literature 10 and 20
Social Studies 10 and 20
Science 10 and 20
General Mechanics 15 and 16
Foods and Nutrition 10 and Fabrics and Dress 10

ii. Students in a school where cycling arrangement is used are reminded that both Grades ten and eleven courses in a sequence must be taken before proceeding to Grade twelve. For example, if a student takes Science 20 as his first year high school science course, he must subsequently take Science 10 before registering in either Physics 30 or Chemistry 30.[1]

Two other possible arrangements are double programming and scheduling

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[1] Senior High School Handbook, (Edmonton: Department of Education, 1956), p. 41.

of certain electives.

> In view of the limitations existing in the small high schools to which this section applies, cycling, double programming and the scheduling of certain electives have been outlined as being acceptable and advantageous practices.[2]

It was felt that if the material in Science 10 and 20 were sequentially arranged, Science 20 may be relatively difficult for the grade ten student and Science 10 may be relatively easy for the grade eleven student. Thus a grade ten student taking Science 20 may not fully understand many of the important concepts which serve as a foundation for Chemistry 30 and Physics 30 and, as there is a one-year interval before grade twelve, he may forget much of this important background material. It is possible for such a student to receive a "C" standing in Science 20, then proceed to Chemistry 30 and Physics 30 if he receives a "B" standing, or better,in Science 10.

The purpose of this study is to determine whether cycling Science 10 and 20 affects achievement in Chemistry 30 and/or Physics 30.

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[2]Ibid., p. 47.

CHAPTER II

DESIGN

There were two main groups in this study, Group A and Group B. Group A was the experimental group, and Group B was the control group.

Group A consisted of those students who took grade nine in 1952-53, Science 20 in 1953-54, Science 10 in 1954-55, Chemistry 30 and/or Physics 30 in 1955-56. Group B consisted of those students who took grade nine in 1953-54, Science 10 in 1954-55, Science 20 in 1955-56, Chemistry 30 and/or Physics 30 in 1956-57. The same 104 schools in Group A made up Group B, that is, all the rural schools in Alberta which were "off cycle"* in 1953-54 and "on cycle"* in 1954-55 and offered grade twelve in 1955-56 and 1956-57. Further restrictions for the selection of students in these schools were:

i. Students must have taken grades nine, ten, eleven and twelve in the same school.

ii. Students must not have repeated any high school science course nor taken any high school science course by correspondence.

Using the same schools in both Groups A and B tended to stabilize the influence of other factors which may affect achievement. Some of these factors may be: change of teachers, qualifications of teachers, size of school, adequacy of library and science laboratory, socio-economic

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*Grades ten and eleven taking Science 20 - off cycle.
Grades ten and eleven taking Science 10 - on cycle.

status and intelligence.

The total rural population was used, making sampling unnecessary. All of the students under study did not take the same grade twelve subjects. Because of the possible effect of transfer of learning, it was necessary to break each of the two main groups into the following sub-groups consisting of those students who took:

1. Chemistry 30 with Mathematics 30 and Physics 30.
2. Chemistry 30 with Physics 30, but not Mathematics 30.
3. Chemistry 30, but not Physics 30 or Mathematics 30.
4. Chemistry 30 with Mathematics 30, but not Physics 30.
5. Physics 30 with Chemistry 30 and Mathematics 30.
6. Physics 30 with Chemistry 30, but not Mathematics 30.
7. Physics 30 with Mathematics 30, but not Chemistry 30.
8. Physics 30, but not Chemistry 30 and Mathematics 30.

Each sub-group was broken into three parts: Boys, Girls, Boys and Girls.

To insure similar sub-groups for comparison, each sub-group in Group A was equated to the corresponding sub-group in Group B on the basis of the grade nine Departmental Examinations in Science and General. The General Examination served as a Mental Ability test. It was felt that these two examinations would have the greatest predictive value for grade twelve Chemistry 30 and Physics 30 achievement than any other combination of two grade nine examinations. To validate this criterion, multiple correlations were found between Chemistry 30 (or Physics 30) and grade nine General and grade nine Science.

Although the parent populations are normal in distribution, many

sub-groups were found to be not normally distributed. Product-moment coefficients of correlation are based upon normal distributions, and therefore the raw scores were changed to "T" scores.

Each sub-group in the Experimental Group was compared by analysis of variance with the corresponding sub-group in the Control Group. This was to insure that corresponding sub-groups were equated as to grade nine General and grade nine Science. Raw scores were used for the analysis of variance. Corresponding sub-groups were then compared, by analysis of variance, according to Chemistry 30 or Physics 30 raw scores.

CHAPTER III

RELATED STUDIES

A search was made of the following sources of educational research:

Educational Index
Encyclopedia of Educational Research
Review of Educational Research
Psychological Abstracts
Journal of Psychological Research
British Journal of Psychological Abstracts
Unpublished Masters' Theses in Education Library

No studies were found which were related to this study of cycling science courses in the high school.

CHAPTER IV

DATA

PART A: SAMPLE SIZE

The statistical procedures used in this study could hardly be justified using sample sizes of twenty-five or less. Therefore, four of the eight sub-groups must be eliminated. These are:

i. Chemistry with Physics, no Mathematics
ii. Physics with Chemistry, no Mathematics
iii. Physics with Mathematics, no Chemistry
iv. Physics, no Chemistry, no Mathematics

In six of the eight sub-groups in Table I, the sample size decreased from 1956 to 1957, in spite of a general increase in the Alberta grade twelve population during this period. Two possible reasons might be advanced to account for this shrinkage. Firstly, the shortage of qualified high school teachers is becoming more acute, especially in rural centralizations. This would force more high school students to take correspondence in certain subjects and/or move to larger centralizations to complete their high school programs and/or take more limited high school programs, especially in grade twelve. Secondly, the Experimental Group included some students who received a "C" standing in Science 20, proceeded to Science 10 and received a "B", or better, standing, then took Chemistry 30 and/or Physics 30. The students in the Control Group received a "C", or better, standing in Science 10, received a "B", or better, standing in Science 20, then proceeded to Chemistry 30

TABLE I

SIZE OF SUB-GROUPS

Sub-Group	Experimental Group A			Control Group B		
	Total	Boys	Girls	Total	Boys	Girls
C with MP	155	95	60	101	69	32
C with P, no M	41	23	18	22	16	6
C with M, no P	180	62	118	196	65	131
C, no MP	128	51	77	93	41	52
P with CM	155	95	60	101	69	32
P with C, no M	41	23	18	22	16	6
P with M, no C	17	13	4	18	14	4
P, no MC	13	10	3	5	4	1

C-Chemistry 30, P-Physics 30, M-Mathematics 30

and/or Physics 30. This means that some students in the Control Group were unable to take Chemistry 30 and/or Physics 30 because of a "C" standing in Science 20 whereas some students in the Experimental Group took Chemistry 30 and/or Physics 30 even though they received a "C" standing in Science 20.

The sample size of two groups:

Chemistry with Mathematics, no Physics, and

Chemistry, no Mathematics, no Physics,

is affected further by equating the groups. This is explained in part B of this Chapter.

PART B: EQUATING GROUPS

In order to insure equal groups for comparing achievement in Chemistry 30 and Physics 30, each part (Boys, Girls, Total) of each sub-group in Group A was equated on the basis of grade nine General and grade nine Science, with the corresponding section (Boys, Girls, Total) of the sub-group in Group B. For example, Girls taking Chemistry 30 with Physics 30 and Mathematics 30 from Group A were equated with Girls taking the same subjects from Group B, on the basis of grade nine General and grade nine Science. The comparison was made by analysis of variance, using the F ratio to test for significance. The F ratio is the comparison of the mean squares (Variance) about the means to the mean squares (Variance) within groups.

The .01 level of significance is chosen because of non-normality of many distributions, even though the parent populations are normally distributed. For analysis of variance the distributions should be normal. However, the significance of analysis of variance is not seriously affected by non-normality, but a more stringent level of significance should be used. Therefore, the .01 level is used instead of the .05 level.

TABLE II

EQUATING GROUPS

Sub-group	N	Grade IX Test	F	Sig. of F
C(MP) Total	256	General	.268	not sig. at .01
P(CM)		Science	.547	not sig. at .01
C(MP) Boys	164	General	.131	not sig. at .01
P(CM)		Science	1.639	not sig. at .01
C(MP) Girls	92	General	.022	not sig. at .01
P(CM)		Science	.378	not sig. at .01
C(M$\not$P) Total	362	General	.396	not sig. at .01
		Science	2.282	not sig. at .01
C(M$\not$P) Boys	124	General	.446	not sig. at .01
		Science	.688	not sig. at .01
C(M$\not$P) Girls	238	General	.088	not sig. at .01
		Science	1.737	not sig. at .01
C(M$\not\phi$) Total	204	General	2.069	not sig. at .01
		Science	2.376	not sig. at .01
C($\not$MP) Boys	81	General	2.902	not sig. at .01
		Science	.967	not sig. at .01
C($\not$MP) Girls	123	General	.267	not sig. at .01
		Science	1.445	not sig. at .01

Symbols:
C-Chemistry 30, P-Physics 30, M-Mathematics 30
$\not\phi$-not Chemistry, $\not$P-not Physics, $\not$M-not Mathematics
e.g., C(M$\not$P) - Chemistry with Mathematics, but not Physics

N is the sum of the populations in Group A and Group B in the respective sub-groups.

N in Table II is not necessarily the sums of the numbers as shown in Table I - Size of Sub-Groups. It was necessary to delete some of the individual scores in six sub-groups:

Chemistry with Mathematics, no Physics - Total, Boys, Girls
Chemistry, no Mathematics, no Physics - Total, Boys, Girls

in order to reach the .01 level of non-significance for grade nine General and grade nine Science. The individuals thus eliminated are not included in the Validation of Criteria or in the Comparison of Achievement. The variances in the other six sub-groups were non-significant at the .01 level for grade nine General and grade nine Science without removing any individual scores.

Details of Table II are shown in Appendix A, and a worked example of the method used in the analysis of variance is included in Appendix B.

PART C: VALIDATION OF CRITERIA

I: NORMALIZING DISTRIBUTIONS

The validation of criteria was done by computing multiple correlations from zero-order correlations. Zero-order correlations were computed by the product-moment method. The basic assumption for this method is that the distributions to be correlated are normally distributed. Many of the sub-groups were found to be not normally distributed, and therefore it was necessary to normalize the distributions. These normalized scores are called "T" scores and represent the percentage of cumulative frequency below the score plus one-half of the given score. The mean is forced to approximate 50 and the standard deviation is forced to approximate 10. (See Appendix C for an example of the method used in calculating "T" scores.)

Figures I, II and III are examples of distributions before and after normalizing scores.

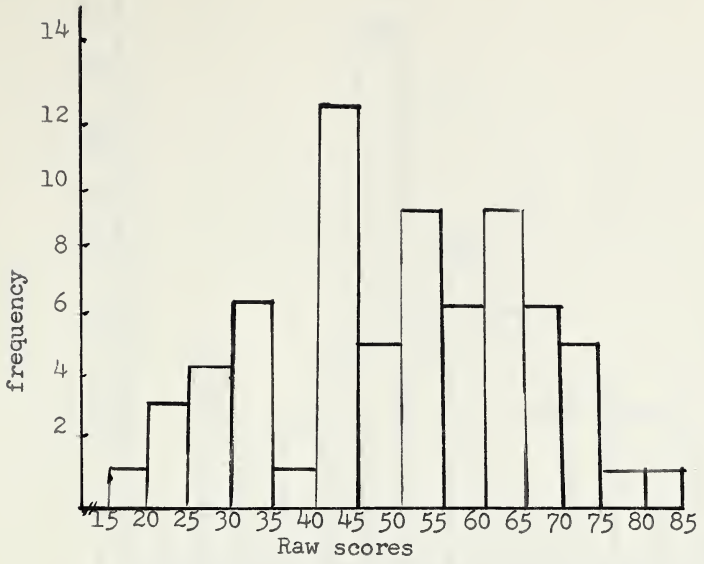

Fig. 1a - Distribution of raw scores in Chemistry 30 in sub-group Chemistry 30 with Mathematics 30 and Physics 30, Boys.

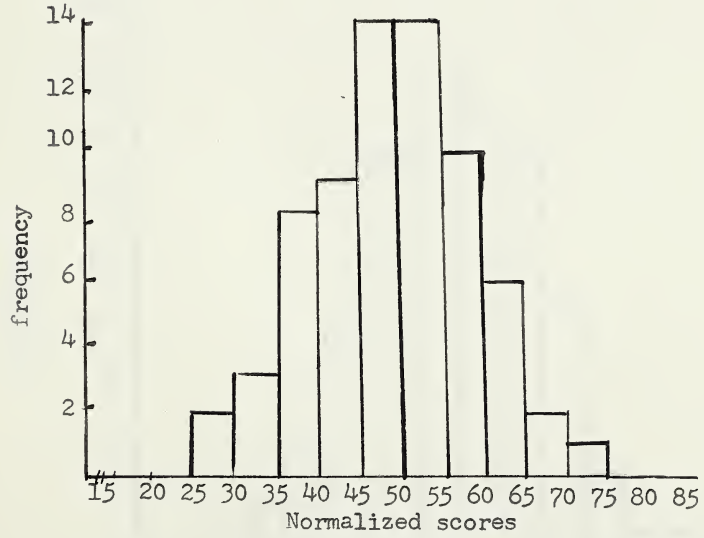

Fig. 1b - Distribution of normalized scores in Chemistry 30 in sub-group Chemistry 30 with Mathematics 30 and Physics 30, Boys.

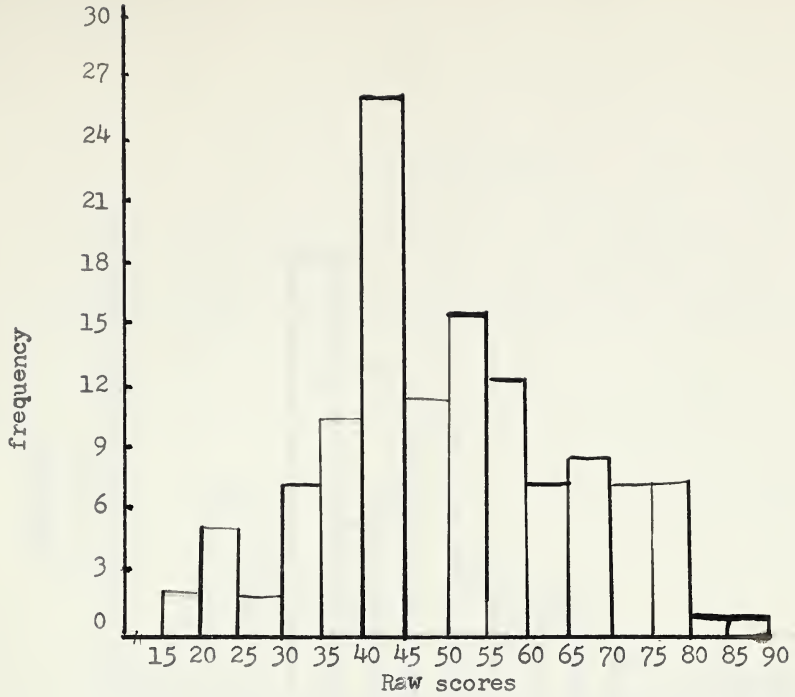

Fig. 2a - Distribution of raw scores in Chemistry 30 in sub-group Chemistry 30 with Mathematics 30 but no Physics 30.

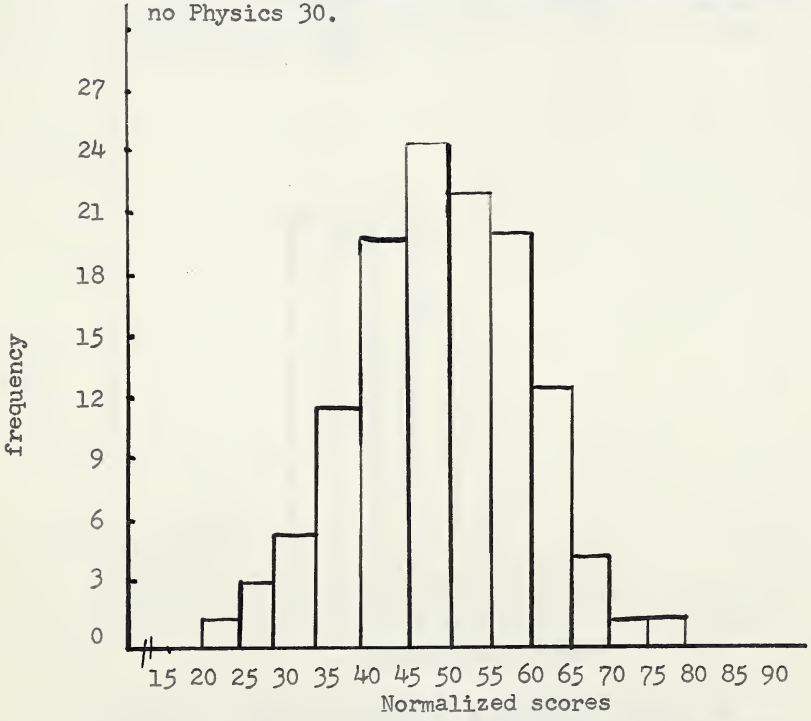

Fig. 2b - Distribution of normalized scores in Chemistry 30 in sub-group Chemistry 30 with Mathematics 30 but no Physics 30.

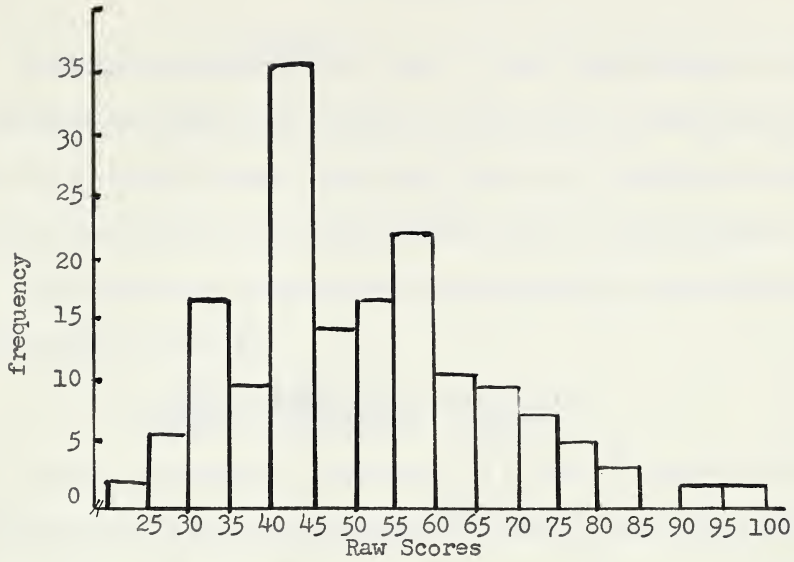

Fig. 3a - Distribution of raw scores in Physics 30 in sub-group Physics 30 with Mathematics 30 and Chemistry 30, Total.

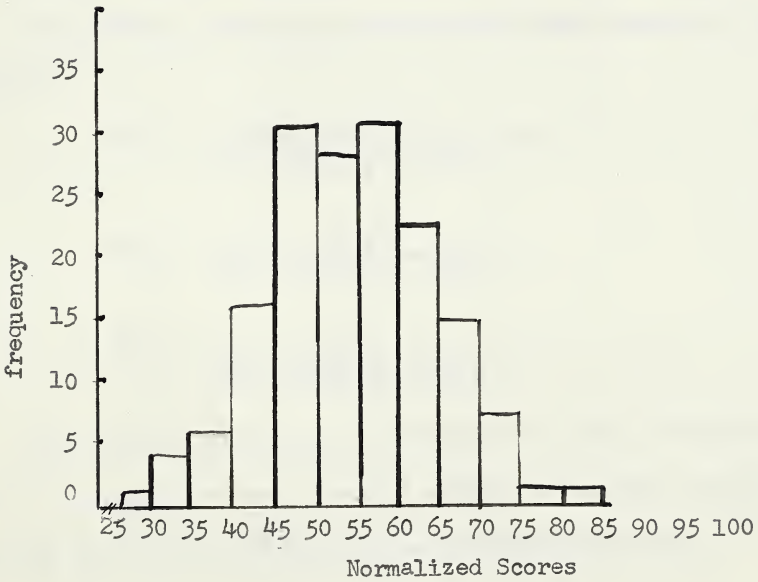

Fig. 3b - Distribution of normalized scores in Physics 30 in sub-group Physics 30 with Mathematics 30 and Chemistry 30, Total.

II. CORRELATIONS

Multiple correlations were used to test the validity of using grade nine General and grade nine Science as the basis for equating sub-groups. Table III gives the various steps involved in the validation procedure. By way of clarification we might describe each of these steps very briefly.

The zero-order correlations were computed by the product-moment method, using the formula[1]

$$r = \frac{N\Sigma XY - \Sigma X\Sigma Y}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$$

where r is the correlation coefficient, X is the $'T'_L$ score in the first distribution and Y the corresponding $'T'_L$ score in the second distribution. An example of the method used in computing zero-order correlation coefficients will be found in Appendix D.

The partial correlation coefficients were computed by the following formulae:[2]

$$r_{12.3} = \frac{r12 - r13\ r23}{\sqrt{1 - r^2 13}\ \sqrt{1 - r^2 23}}$$

$$r_{13.2} = \frac{r13 - r12r23}{\sqrt{1 - r^2 12}\sqrt{1 - r^2 23}}$$

$$r_{23.1} = \frac{r23 - r12r13}{\sqrt{1 - r^2 12}\sqrt{1 - r^2 13}}$$

The partial correlation coefficient is used to determine the relationship of two variables when possible effects of another variable or variables have been partialled out from the zero order correlation.

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[1] Henry E. Garrett, Statistics in Psychology and Education (New York: Longmans, Green and Co., 1953), p. 142.

[2] Ibid, p. 381.

TABLE III

VALIDATION OF CRITERIA - GROUP A

Group	r_{12}	.01	r_{13}	.01	r_{23}	.01	$r_{12.3}$	$r_{13.2}$	$r_{23.1}$	σ(est.X_1)	$R_{1(23)}$	.01	$R^1_{1(23)}$	.01	N
C(MP)T	.3162	Y	.3895	Y	.4599	Y	.139	.290	.279	8.93	.412	Y	.399	Y	155
C(MP)M	.2803	Y	.3624	Y	.5444	Y	.106	.260	.494	9.22	.375	Y	.349	Y	95
C(MP)F	.4033	Y	.4238	Y	.4129	Y	.276	.308	.291	8.55	.491	Y	.463	Y	60
C(M$\not$P)T	.2678	Y	.4530	Y	.4060	Y	.103	.392	.331	8.90	.462	Y	.452	Y	180
C(M$\not$P)M	.2334	N*	.4432	Y	.4157	Y	.060	.392	.357	8.89	.444	Y	.412	Y	62
C(M$\not$P)F	.2872	Y	.4744	Y	.4020	Y	.119	.409	.315	8.66	.488	Y	.474	Y	118
C($\not$MP)T	.0391	N*	.2159	N	.4060	Y	-.072	.256	.410	9.59	.263	N	.233	N	128
C($\not$MP)M	-.0090	N*	.1135*	N	.3834	Y	-.057	.119	.385	9.88	.121	N*	---	N*	51
C($\not$MP)F	.0499	N*	.2910	N	.5327	Y	-.130	.312	.380	9.51	.314	N	.272	N*	77
P(MC)T	.4032	Y	.4580	Y	.4599	Y	.244	.335	.338	8.54	.507	Y	.497	Y	155
P(MC)M	.3400	Y	.4342	Y	.5444	Y	.136	.315	.467	9.05	.448	Y	.428	Y	95
P(MC)F	.5338	Y	.5664	Y	.4129	Y	.400	.447	.158	7.57	.653	Y	.637	Y	60

* - Not significant at the .05 level
C - Chemistry 30, P - Physics 30, M - Mathematics 30
$\not$ - not Chemistry 30, $\not$P - not Physics 30, $\not$M - not Mathematics 30
1 - Chemistry 30 (or Physics 30), 2 - Grade nine General, 3 - Grade nine Science

TABLE IV

VALIDATION OF CRITERIA - GROUP B

Group	r_{12}	.01	r_{13}	.01	r_{23}	.01	$r_{12.3}$	$r_{13.2}$	$r_{23.1}$	$\sigma_{(est.X_1)}$	$R_{1(23)}$	.01	$R_{1(23)}$	.01	N
C(MP)T	.3930	Y	.5450	Y	.4022	Y	.227	.459	.245	7.71	.576	Y	.564	Y	101
C(MP)M	.4018	Y	.5092	Y	.4939	Y	.200	.389	.366	8.33	.536	Y	.515	Y	69
C(MP)F	.2518	N*	.6577	Y	.2932	N*	.082	.630	.175	7.24	.659	Y	.629	Y	32
C(M$\not$P)T	.2078	Y	.4657	Y	.3783	Y	.039	.428	.326	8.80	.498	Y	.489	Y	182
C(M$\not$P)M	.1708	N*	.4528	Y	.3737	Y	.002	.425	.326	8.81	.465	Y	.435	Y	62
C(M$\not$P)F	.2386	N	.5032	Y	.3715	Y	.064	.460	.299	8.63	.507	Y	.494	Y	120
C($\not$MP)T	.2697	N	.4058	Y	.2402	N	.195	.365	.149	9.24	.439	Y	.413	Y	76
C($\not$MP)M	.2592	N*	.5114	Y	.3440	N*	.103	.465	.254	8.21	.523	N	.469	N	30
C($\not$M$\not$P)F	.2356	N*	.4588	Y	.1560	N*	.187	.440	.056	8.67	.490	Y	.452	Y	46
P(MC)T	.5070	Y	.5014	Y	.4022	Y	.336	.377	.173	8.01	.604	Y	.593	Y	101
P(CM)M	.4870	Y	.5341	Y	.4939	Y	.302	.386	.316	7.94	.597	Y	.580	Y	69
P(CM)F	.4695	Y	.4867	Y	.2932	N*	.392	.413	.084	7.99	.593	Y	.554	Y	32

* - not significant at the .05 level
C - Chemistry 30, P - Physics 30, M - Mathematics 30
$\not$ - not Chemistry 30, $\not$P - not Physics 30, $\not$M - not Mathematics 30
1 - Chemistry 30 (or Physics 30), 2 - Grade nine General, 3 - Grade nine Science

$R_{1(23)}$ is the multiple correlation between Chemistry 30 (or Physics 30) and the battery of grade nine General and grade nine Science. This was computed by the following formula:[3]

$$R_{1(23)} = \sqrt{1 - \frac{\sigma^2_{1.23}}{\sigma^2_1}}$$

where $\sigma^2_{1.23}$ is the standard deviation squared when Chemistry 30 (or Physics 30) is freed of the influence of variability exerted upon it by the effect of grade nine General and grade nine Science. R is the correlation coefficient between scores estimated by the multiple regression equation and the actual scores obtained. Stated differently, R x 100 is the percentage of times the estimate of scores from the multiple regression equation will be within the standard error of estimate.

An example of the method used in calculating Multiple correlations will be found in Appendix E.

(X_1) is the standard error of estimate of Chemistry 30 (or Physics 30) based upon the multiple regression equation[4]

$$(X_1 - M_1) = b_{12.3}\,(X_2 - M_2) + b_{13.2}\,(X_3 - M_3)$$

where X_1 is the Chemistry 30 (or Physics 30) score to be predicted, M_1 is the mean of the scores in Chemistry 30 (or Physics 30), X_2 is the score in grade nine General. M_2 is the mean of the scores in grade nine General, X_3 is the score in grade nine Science, M_3 is the mean of the

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[3] Ibid., p. 381.

[4] Ibid., p. 385.

scores in grade nine Science, $b_{12.3} = \beta_{12.3} \frac{\sigma_{1.23}}{\sigma_{2.13}}$ and $b_{13.2} = \beta_{13.2} \frac{\sigma_{1.23}}{\sigma_{3.12}}$

Thus, if $X_1 = 8.93$, then the estimate of a student's score in Chemistry 30 based on his scores in grade nine General and grade nine Science will be within 8.93 points of his real score in Chemistry 30 approximately two-thirds of the time.

N is the number of individuals in each sub-group. $R^1_{1(23)}$ is the multiple correlation coefficient after the correction for shrinkage has been found. This formula is:[5]

$$R^1_{1(23)} = \sqrt{1 - (1-r^2 1.23)\left(\frac{N-1}{N-n}\right)}$$

where N is the sample size and n is the number of variables (in this study n is three). This corrects the positive bias of the nultiple correlation coefficients.

The significance of the zero-order correlations, the multiple correlations and the multiple correlations after shrinkage are given at the .01 level of significance. The coefficients which are significant at the .01 level are naturally significant also at the .05 level. Those coefficients which are not significant at the .01 level are tested for significance at the .05 level. Those which are not significant at the .05 level are marked with an asterisk. Tables IV and V emphasize significance at the .01 level but it should be remembered that the .05 level of significance is adequate.

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[5]Quinn McNemar, Psychological Statistics (New York: John Wiley and Sons, 1955), p. 186.

From Group A there are seven zero-order correlations which are not significant at the .01 level. Five of these correlations are also not significant at the .05 level. From Group B there are ten correlations which are not significant at the .01 level. Eight of these are not significant at the .05 level. This would indicate that neither the grade nine General nor the grade nine Science alone would be an adequate basis for equating groups for comparison of achievement in Chemistry 30 or Physics 30.

From Group A, after shrinkage, there are three multiple correlations which are not significant at the .01 level. Two of these are not significant at the .05 level. This means that, choosing the .05 level of significance, the battery of grade nine General and grade nine Science is not a valid basis for predicting grade twelve achievement in Chemistry 30 for those students (boys and girls, but not Total) who are not taking Physics 30 and Mathematics 30. This means that any conclusions about these sub-groups in this study are of doubtful value.

From Group B, after shrinkage, one multiple correlation is not significant at the .01 level but all multiple correlations after shrinkage are significant at the .05 level.

The reason for all the multiple correlations after shrinkage being significant at the .05 level and two of the multiple correlations after shrinkage being not significant has not been determined. However, one reason may be that Group A is more homogeneously grouped than Group B. This may be indicated by the standard error of estimate. The standard error of estimate for the groups in question is larger for

Group A than for Group B.

All of the multiple correlations after shrinkage in Group B are larger than the corresponding multiple correlations after shrinkage in Group A except one, P(CM). This means that the battery of grade nine General and grade nine Science gives a higher prediction of achievement in Chemistry 30 and Physics 30 in Group B than the battery in Group A. This may indicate that cycling Science 10 and 20 has affected the Sub-Groups in the Experimental Group A in a manner that has not been determined in this study.

PART D: COMPARISON OF ACHIEVEMENT

A comparison of achievement of each sub-group with respect to Chemistry 30 or Physics 30 was made by analysis of variance. The same stringency of significance applies for comparison of groups as with equating groups, that is, the .01 level of significance of the F ratio is used. Analysis of variance assumes normality of populations but is not seriously affected by non-normality if a stringent level of significance, usually .01, is chosen. Table V summarizes the analysis of variance. More complete details of the analysis of variance for comparison of sub-groups is given in Appendix F.

Table V shows that there was no significant difference (at the .01 level) between the corresponding sub-groups. At the .05 level of significance there was one sub-group which showed a significance of difference. This sub-group was Chemistry, but neither Physics nor Mathematics, Girls. The F value of 3.986 was slightly larger than the minimum significant value from the F Table, 3.945, at the .05 level (by linear interpolation).

TABLE V

COMPARISON OF ACHIEVEMENT

Sub-group	N	Grade XII Test	F	Sig. of F
C(MP) TOTAL	256	Chemistry 30	.001	not sig. at .01
C(MP) BOYS	164	Chemistry 30	.412	not sig. at .01
C(MP) GIRLS	92	Chemistry 30	.906	not sig. at .01
C(MP) TOTAL	362	Chemistry 30	.001	not sig. at .01
C(MP) BOYS	124	Chemistry 30	.008	not sig. at .01
C(MP) GIRLS	238	Chemistry 30	.012	not sig. at .01
C(MP) TOTAL	204	Chemistry 30	.003	not sig. at .01
C(MP) BOYS	81	Chemistry 30	.276	not sig. at .01
C(MP) GIRLS	97	Chemistry 30	3.986	not sig. at .01
P(CM) TOTAL	256	Physics 30	.190	not sig. at .01
P(CM) BOYS	164	Physics 30	1.698	not sig. at .01
P(CM) GIRLS	92	Physics 30	.730	not sig. at .01

N - the sum of corresponding sub-groups

F - the ratio of Variance between means to Variance within classes

CHAPTER V

SUMMARY AND CONCLUSIONS

The multiple correlations used to test the validation of criteria showed, at the .05 level, that the criteria were valid for twenty-two sub-groups but not valid for two sub-groups. At the .01 level the criteria were valid for twenty sub-groups but not valid for four sub-groups. As the .05 level of significance could be used, all but two of the sub-groups showed that the battery of grade nine General with grade nine Science could be used as a basis from which to predict Chemistry 30 and Physics 30 scores, but it should be noted that the validation generally was not high. The correlation coefficient squared (Variance) indicated that much of the variance of most sub-groups was unaccounted for in this study. This would indicate that a better basis for the equating of groups may have given different results in the comparison of achievement in Chemistry 30 or Physics 30.

The results for the two sub-groups, Chemistry 30 but no Mathematics 30 or Physics 30, Boys and Chemistry 30 but no Mathematics 30 or Physics 30, Girls, are not valid because of inadequate equating of groups.

The sample sizes indicate that cycling Science 10 and 20 may have other effects which were not measured in this study.

Within the limitations of this study, cycling Science 10 and 20 has no significant effect upon achievement in Chemistry 30 or Physics 30. Such a finding may appear to be somewhat surprising in view of the normal

approach to curriculum development where attempts are made to insure a logical progression from grade to grade. However, Science 10 deals predominantly with Physics while Science 20 on the other hand deals with Chemistry. Consequently the degree of correlation is probably quite small. Where students taking Science 20 first might benefit from a knowledge of Science 10 facts, teachers may very well adapt lesson plans to fill in such gaps. In this sense then one would not expect cycling to have any pronounced effects on either Chemistry 30 or Physics 30.

CHAPTER VI

RECOMMENDATIONS AND AREAS FOR FURTHER STUDY

Poor predictive instruments at grade nine level for success in grade twelve suggest the need for better criteria at grade nine than the Departmental examinations. Although the majority of the validations were significant, in most cases a large amount of variance was unaccounted for. If better criteria were found a future study might use analysis of covariance to determine significance of achievement. Again, a longitudinal study would probably be the most effective method.

As an administrative device, the policy of cycling Science 10 and 20 appears to be sound. In teaching Science 10 and 20, teachers must constantly be aware of the background of the students and must teach the necessary concepts of science to enable cycled students to grasp the concepts of the science course they are currently taking.

Cycling other subjects in grade ten and eleven may have different results on the achievement in grade twelve.

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APPENDIX A

EQUATING GROUPS

Sub-Group	Grade IX Test	df	SS	MS(V)	F	Sig. of F .05	Sig. of F .01
C(MP) P(CM) TOTAL	General	1	70.42	70.42	.268	No	No
		254	66697.58	262.59			
	Science	1	104.92	104.92	.547	No	No
		254	48679.81	191.65			
C(MP) P(CM) BOYS	General	1	37.46	37.46	.131	No	No
		162	46317.49	285.91			
	Science	1	292.87	292.87	1.639	No	No
		162	28953.08	178.72			
C(MP) P(CM) GIRLS	General	1	105.27	105.27	.022	No	No
		90	437038.60	4855.98			
	Science	1	67.00	67.00	.378	No	No
		90	15955.83	177.29			
C(MP) TOTAL	General	1	88.23	88.23	.396	No	No
		360	80191.08	222.75			
	Science	1	430.09	430.09	2.282	No	No
		360	67852.53	188.48			
C(MP) BOYS	General	1	99.36	99.36	.446	No	No
		122	27154.60	222.58			
	Science	1	126.01	126.01	.688	No	No
		122	22330.59	183.04			
C(MP) GIRLS	General	1	19.66	19.66	.088	No	No
		236	52924.16	224.25			
	Science	1	314.51	314.51	1.737	No	No
		236	42724.99	181.04			

EQUATING GROUPS (CONTINUED)

Sub-Group	Grade IX Test	df	SS	MS(V)	F	Sig. of F .05	Sig. of F .01
C(M̸P̸) TOTAL	General	1 202	401.97 39240.07	401.97 194.26	2.069	No	No
	Science	1 202	401.87 34164.54	401.87 169.13	2.376	No	No
C(M̸P̸) BOYS	General	1 79	463.37 12614.85	463.37 159.68	2.902	No	No
	Science	1 79	153.53 12537.83	153.53 158.71	.967	No	No
C(M̸P̸) GIRLS	General	1 121	68.10 30910.50	68.10 255.46	.267	No	No
	Science	1 121	251.86 21092.01	251.86 174.31	1.445	No	No

SS-Sums of Squares, MS(V)-Mean Square (Variance)
C-Chemistry 30, P-Physics 30, M-Mathematics 30
C̸-no Chemistry 30, P̸-no Physics 30, M̸-no Mathematics 30

APPENDIX B

AN EXAMPLE TO SHOW THE METHOD USED IN THE ANALYSIS OF VARIANCE[1]

Comparison of scores in grade nine Science, Experimental versus Control, of Sub-Group Chemistry with Physics and Mathematics, Boys.

Experimental Group	Control Group
N_1 = size = 95	N_2 = size = 69
M_1 = mean = 67.568	M_2 = mean = 70.275
$\Sigma X_1 = 6419$	$\Sigma X_2 = 4849$
$\Sigma X_1^2 = 451,737$	$\Sigma X_2^2 = 351,703$
$(\Sigma X_1)^2 = 41,203,561$	$(\Sigma X_2)^2 = 23,512,801$

A. Sums of Squares

1. Correction: $\dfrac{(6419 + 4849)^2}{95 + 69} = 774,194.05$

2. SS_T = Sum of squares about general mean

$= 451,737 + 351,703 - 774,194.05 = 29,245.95$

3. $SS_{M'S}$ = Sum of squares between means

$= \dfrac{41,203,561}{95} + \dfrac{23,512,801}{69} = 774,194.05$

$= 292.87$

4. SS_W = Sum of squares within groups

$= 29,245.95 - 292.87 = 28,953.08$

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[1]Henry E. Garrett, Statistics in Psychology and Education (New York: Longmans, Green and Co., 1953), p. 282.

AN EXAMPLE TO SHOW THE METHOD USED IN THE ANALYSIS OF VARIANCE (CONTINUED)

B. Analysis of Variance

Source	df	SS	MS(V)
Between means	1	292.87	292.87
Within classes	162	28,953.08	178.72
	163	29,245.95	

$$F = \frac{292.87}{178.72} = 1.639$$

From Table F (at df = 150)

F at .05 level = 3.90
F at .01 level = 6.81

The F ratio of 1.639 is less than either of the values from the F table for .05 and .01 levels, and therefore there is no significant difference between these groups.

APPENDIX C

AN EXAMPLE TO SHOW THE METHOD USED TO CALCULATE "T" SCORES[2]

Grade nine Science of Sub-Group Chemistry 30 but no Mathematics 30 or Physics 30, Total.

Raw Score	f	Cum. f	Cum. f below score + $\frac{1}{2}$ of given score	Last column in percent	T-score[3]
81	1	76	75.5	99.66	77
80					
79					
78					
77					
76					
75	1	75	74.5	98.34	71
74					
73					
72					
71	1	74	73.5	97.02	69
70	3	73	71.5	94.38	66
69					
68	1	70	69.5	91.74	64
67	1	69	68.5	90.42	63
66	3	68	66.5	87.78	62
65					
64	2	65	64	84.48	60
63	3	63	61.5	81.18	59
62					
61	2	60	59	77.88	58
60	4	58	56	73.92	56
59	3	54	52.5	69.30	55
58	1	51	50.5	66.66	54
57	2	50	49	64.68	54
56	2	48	47	62.04	53
55	2	46	45	59.40	52
54	9	44	39.5	52.14	51

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[2] Ibid., p. 309.

[3] Ibid., p. 433.

AN EXAMPLE TO SHOW THE METHOD USED TO CALCULATE "T" SCORES (CONTINUED)

Raw Scores	f	Cum. f	Cum. f below score + ½ of given score	Last column in percent	T-score
53	2	35	34	44.88	49
52	4	33	31	40.92	48
51					
50	3	29	27.5	36.30	47
49	6	26	23	30.36	45
48	2	20	19	25.08	43
47	1	18	17.5	23.10	43
46	3	17	15.5	20.46	42
45	1	14	13.5	17.82	41
44	2	13	12	15.84	40
43					
42					
41	3	11	9.5	12.54	38
40					
39					
38					
37	2	8	7	9.24	37
36	2	6	5	6.60	35
35					
34	1	4	3.5	4.62	33
33					
32					
31					
30	1	3	2.5	3.30	31
29					
28					
27					
26	1	2	1.5	1.98	29
25					
24	1	1	0.5	.66	25
	76				

APPENDIX D

AN EXAMPLE TO SHOW THE METHOD USED IN COMPUTING ZERO-ORDER CORRELATIONS[4]

Physics 30 versus grade nine Science from the Sub-Group Physics 30 with Mathematics 30 and Chemistry 30, Girls.

$$r = \frac{N\Sigma XY - \Sigma X \Sigma Y}{\sqrt{[N\Sigma X^2 - (\Sigma X)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$$

where X represents the Physics 30 scores and Y represents the grade nine Science scores.

$$r = \frac{9,170,280 - 8,982,005}{\sqrt{(9,315,900 - 8,970,025)(9,353,700 - 8,994,001)}}$$

$$= \frac{188,275}{352,720} = 0.5338$$

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[4] Ibid., p. 142.

APPENDIX E

AN EXAMPLE TO SHOW THE METHOD USED TO CALCULATE MULTIPLE CORRELATIONS[5]

Chemistry 30 versus grade nine General versus grade nine Science from Sub-Group Chemistry 30 with Mathematics 30 but no Physics 30, Total.

(1) Chemistry	(2) General	(3) Science
$M_1 = 49.94$	$M_2 = 49.94$	$M_3 = 50.08$
$\sigma_1 = 10.037$	$\sigma_2 = 9.859$	$\sigma_3 = 9.999$
$r_{12} = 0.2678$	$r_{13} = 0.4530$	$r_{23} = 0.4060$

$$r_{12.3} = \frac{r_{12} - r_{13}r_{23}}{\sqrt{1 - r_{13}^2}\sqrt{1 - r_{23}^2}} = \frac{.2678 - .4530 \times .4060}{.8930 \times .9121} = .1030$$

$$r_{13.2} = \frac{r_{13} - r_{12}r_{23}}{\sqrt{1 - r_{12}^2}\sqrt{1 - r_{23}^2}} = \frac{.4530 - .2678 \times .4060}{.9629 \times .9121} = .3920$$

$$r_{23.1} = \frac{r_{23} - r_{12}r_{13}}{\sqrt{1 - r_{12}^2}\sqrt{1 - r_{13}^2}} = \frac{.4060 - .2678 \times .4530}{.9629 \times .8930} = .3309$$

$$\sigma_{1.23} = \sigma_1\sqrt{1 - r_{12}^2}\sqrt{1 - r_{13.2}^2} = 10.037 \times .9629 \times .9208 = 8.900$$

$$\sigma_{2.13} = \sigma_2\sqrt{1 - r_{23}^2}\sqrt{1 - r_{12.3}^2} = 9.859 \times .9121 \times .9950 = 8.947$$

$$\sigma_{3.12} = \sigma_3\sqrt{1 - r_{23}^2}\sqrt{1 - r_{13.2}^2} = 9.999 \times .9121 \times .9208 = 8.398$$

$$\sigma(\text{est.}X_1) = \sigma_{1.23} = 8.900$$

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[5] Ibid., p. 391.

AN EXAMPLE TO SHOW THE METHOD USED TO CALCULATE MULTIPLE CORRELATIONS (CONTINUED)

$$R_{1(23)} = \sqrt{1 - \frac{\sigma^2_{1.23}}{\sigma^2_1}} = \sqrt{1 - \frac{79.210}{100.741}}$$

$$= 0.462$$

APPENDIX F

COMPARISON OF ACHIEVEMENT IN CHEMISTRY 30
COMPARISON OF ACHIEVEMENT IN PHYSICS 30

Sub-Group	Grade XII Test	df	SS	MS(V)	F	Sig. of F .05	Sig. of F .01
C(MP) TOTAL	Chemistry	1 254	.21 60423.79	.21 237.89	.001	No	No
C(MP) BOYS	Chemistry	1 162	95.91 37704.65	95.91 232.74	.412	No	No
C(MP) GIRLS	Chemistry	1 90	198.14 19681.82	198.14 218.69	.906	No	No
C(MP') TOTAL	Chemistry	1 360	.18 79766.28	.18 221.57	.001	No	No
C(MP') BOYS	Chemistry	1 122	2.06 29766.68	2.06 243.99	.008	No	No
C(MP') GIRLS	Chemistry	1 236	2.59 49888.19	2.59 211.39	.012	No	No
C(M'P) TOTAL	Chemistry	1 202	7.17 46203.75	7.17 228.73	.003	No	No
C(M'P) BOYS	Chemistry	1 79	59.21 16953.01	59.21 214.60	.276	No	No
C(M'P) GIRLS	Chemistry	1 95	864.50 20603.87	864.50 216.88	3.986	Yes	No

COMPARISON OF ACHIEVEMENT IN CHEMISTRY 30
COMPARISON OF ACHIEVEMENT IN PHYSICS 30
(CONTINUED)

Sub-Group	Grade XII Test	df	SS	MS(V)	F	Sig. of F .05	Sig. of F .01
P(CM)	Physics	1	37.52	37.52	.190	No	No
TOTAL		254	50070.48	197.13			
P(CM)	Physics	1	340.73	340.73	1.698	No	No
BOYS		162	32501.14	200.62			
P(CM)	Physics	1	143.80	143.80	.730	No	No
GIRLS		90	16494.50	183.27			

APPENDIX G

SOURCE OF INFORMATION

All data for this study was found in the files of the Department of Education, Edmonton, Alberta.

The names of the schools which cycled were found on the Form A cards. The names of the students who took grade twelve in these schools, and the grade twelve marks obtained by these students, were found on the class lists of the Departmental Examination Results. The Principals' Confidential Reports of the year previous indicated whether these individual students did cycle Science 10 and 20 and also indicated whether these students took grade ten and grade eleven in the same schools as they took grade twelve. Then these students' individual grade nine cards showed whether they took grade nine in the same school and also showed their grade nine marks. The students' names were eliminated from the study if they failed to meet all the criteria as explained in the design.